

TEST EFFECTIVENESS TREND OBSERVATION

Effectiveness of Galileo Assembly Level Dynamics Tests

CONCLUSION:

Based on Galileo program experience, assembly level sine vibration testing is the most effective of all the assembly level dynamics tests in revealing design and workmanship flaws. The second most effectiveness assembly level dynamics test is random vibration.

DISCUSSION:

The following table summarizes the dynamics environments test history on Galileo assemblies for the 1986 launch opportunity:

Table 1. Dynamic Test Failures vs. Test Environment

Test Env.	Total Tests			Failures			Yield	
	Qual/ PF	FA	Total	Qual/ PF	FA	Total	Relative To All Tests	Relative to Specific Envir.
1. Random Vib.	66	46	112	6	4	10	4.0%	8.9%
2. Sine Vib	66	46	112	16	9	25	9.9%	22.3%
3. Sine or Random*	--	--	--	16	12	28	11.1%	UNK
4. Shock	14	0	14	1	--	1	0.4%	7%
5. Acoustic	14	0	14	2	--	2	0.8%	14%
Total	160	92	252	41	25	66	26.2%	--

* Could not be determined if failure occurred during sine or random vibration.

The second table, Table 2 provided below, was developed by distributing the failures attributed to "sine or random" vibration (Item 3 in Table 1 above) to each of the sine and random vibration environments in the same proportion as failures were found for each of those environments as indicated in Table 1. For example, 10/35 of the 28 failures attributed to sine or random, or 8, were added to the total column for random vibration. Distributing failures in this way leads to fractional failures in the Qual/PF and FA columns, but this has no significance other than providing the values required for the correct numerical distribution.

Table 2. Dynamic Test Failures with Distributed Unknown Test Environment

Test Env.	Total Tests			Failures			Yield	
	Qual/ PF	FA	Total	Qual/ PF	FA	Total	Relative To All Tests	Relative to Specific Env.
1. Random Vib	66	46	112	10.4	7.7	18	7.1%	16.1%
2. Sine Vib	66	46	112	27.6	17.3	45	17.9%	40.2%
3. Sine or Random	--	--	--	--	Dist	--	--	--
4. Shock	14	0	14	1	--	1	0.4%	7%
5. Acoustic	14	0	14	2	--	2	0.8%	14%
Total	160	92	252	41	25	66	26.2%	--

As can be calculated from the tables, the largest number of assembly test failures, 38%, or 68% if failures attributed to sine or random are redistributed, resulted from the sine vibration test. Random vibration testing was identified as the cause of failure in 15% (27%) of the cases. Pyrotechnic shock and acoustic noise testing was performed only on those assemblies deemed to be particularly sensitive to these environments. They resulted in 1.5% and 3% of the failures, respectively. The ratio of the total number of failures (66) to the total number of tests (252) is just greater than one in four (26.2%).

There are several possible reasons for this effectiveness of the sine vibration test:

1. The sine vibration is almost always the first test type to which the assembly is subjected with the result that many failures occur before the first random vibration is applied,
2. The launch transient events the sine test is intended to simulate are a severe environment for assemblies,
3. The designs were overly susceptible and should have been more conservative,
4. Workmanship/fabrication was inadequate,
5. The sine test is an overly conservative simulation of the launch transient environment, or
6. Some combination of the above.

The results may also be influenced by other test sequence factors. Typically, the vibration and shock tests were completed in one axis before proceeding to the next axis. The acoustic tests were usually performed after completion of the three axes of vibration and shock.

It is also interesting to note that of the 25 Flight Acceptance level test failures, nearly 70% were caused by the sine test, if it is assumed that failures attributed to sine or random are distributed as shown in the Table 2. This differs from industry experience, which indicates that random vibration is a more effective workmanship screen. Sine vibration test failures included out-of-spec performance, loosened screws and nuts, sheared rivets, covers prematurely deployed, broken electronic connectors, paint flakes and other contaminants, ruptured flex hoses, and deformed or broken brackets, thermal isolators, mounting feet, and housings.